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# THE EFFECTS OF DIFFERENT COVER CROPS ON GRAIN YIELD OF POPCORN (*ZEA MAYS* L. SSP. *EVERTA* STURT)

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## *ABSTRACT*

*Cover crops are specific system of growing and mainly cover the surface of the soil during the winter, improve the physical and mechanical properties of the soil, water regime, increase the content of nutrients, reduce weed control and contribute to the achievement of higher yields of the main crops. The positive impact on the higher yields in the main crop is the result of lower infestation and increased competition for the main factors of growth and development and through secretion allelopathic compounds.*

*The experiments were performed in 2014 on experimental field of the Maize Research Institute in ZemunPolje (Belgrade, Serbia). We have includedthe following types of individual winter cover crops: common vetch, oat, fodder kale and field pea; Mixtures: common vetch + oats, field pea + oats; and two controltreatments:deadorganicmulch-soilcovered with strawin autumnand winter time, andconventional (traditional) variant–bare soiluncoveredduring fall andwinter time. Sowing cover crops is carried out in the autumn, the elemental plots of 35 $m^{-2}$. Mowing and soil incorporation of cover crops was carried out in late April or early May, when the crops were most abundant. Sowing popcorn (ZP 611k) was done manually in mid-May at a density of 65 000 plants $ha^{-1}$. In both years, in the phase of intensive growth of the main crop, is determined total number of weed species, total number of plants per species and fresh biomass per $m^{-2}$.*

*In a year that was rich precipitation (2014), the highest grain yield obtained with legumes cover crops and the lowest in traditional variant, classical plowing in the fall and keeping bare land uncovered during the winter. We can be concluded that higher yields of popcorn by sowing cover crops in sustainable farming systems in a semi - arid regions.*

## *INTRODUCTION*

Maize is grown primarily as an energy crop, but a broad use of various specific types such as sweet corn, popcorn and corn white beans. Maize types with specific traits are present that require special attention, both in the process of breeding and seed production process, in the commercial production and refining process (Pajić, 2007). The main trait that distinguishes popcorn from other maize types is the formation of large "flakes" or "popcorn" after the explosion as a response to warming. In addition, they differ in the structure, shape and size of the grains. The high level of hard endosperm is highly correlated with the popping volume. The greater economic importance are varieties and hybrids with spherical grains (Pajić et al., 2005)

Popcorn is cultivated in prehistoric times before 4500. Transferring and expansion of corn in the world increases the production of popcorn. Popcorn has become a commercial culture for more than 100 years, and the popularity and consumption is rapidly increasing since 1940. One of the largest manufacturers of popcorn in the world is America. Nebraska is currently the leading manufacturer of popcorn because of the high

percentage of coverage irrigation systems. Pajic et al. (2012) examined the yield of the 12 maize hybrids and pointed out that the yield in Serbia ranged from 3,556 to 6,086 kg / ha.

In order to meet the maximum genetic potential, harvesting must be done in the full maturity of grain to grain moisture content does not exceed 16-18%. High quality hybrid popcorn must have high and stable yield and high level of popping and quality of flakes, which represents a major challenge for growers and breeders.

Manufacturers want high returns, strong stems and good resistance to disease and the consumer wants a high bellow and good taste. Current commercial hybrids involve some compromise between these demands. The most suitable land for the cultivation of popcorn are medium to coarse-textured soil (with adequate rainfall or irrigation additionally).

Environmental factors affect yield and yield-related components of corn (Gökmen et al., 2001; Oz and Kapar, 2011). In addition, to achieve an ideal plant population, it is necessary to consider some technical features, such as: cultivar, plant spacing distribution, soil fertility and moisture content, planting season, expected yield, and the technology level adopted by farmers (Sánchez et al., 2010).The most important benefit of cover crops in corn production is its potential for increased yield. For the introduction of the system of cover crops growing popcorn has a lot of justification, especially in terms of increasing grain yield through reduction of weed infestation, soil protection and reduce the application of fertilizers. The objective of this study was to determine the effect of different winter (dead mulch) cover crops and their mixtures with oats on grain yield of popcorn.

## MATERIAL AND METHODS

The experiment included four kinds of winter cover crops (common vetch, oat, fodder kale and field pea as well mixtures of legume crops with oats), another variant in which the land was covered with dead organic mulch, and traditional variant, classical plowing in the fall and keeping bare land uncovered during the winter (factor B).All of the varieties being used as a cover crops belongs to Novi Sad Field Crops Institute. Crops were grown under rainfed conditions.

Field experiments were conducted in 2013/14 at Maize Research Institute, ZemunPolje, in the vicinity of Belgrade (44°52'N 20°20'E). The soil was slightly calcareous chernozem with 47% clay and silt, and 53% of sand. The soil properties in layer 0-30-cm of depth were fallow: 3.22% organic matter, 0.19% total N, 1.9% organic C, 16.2 and 22.4 mg per 100 g soil of available $P_2O_5$ and extractable $K_2O$, respectively, 1.38% total $CaCO_3$ and pH 7.3. The experiments were located in different plots in each year and winter wheat was the previous crop. Fallowing nitrogen fixation rates in legume crops, as well recommended fertilization, we came up to the required amount of macronutrients for popcorn (120 kg $ha^{-1}$ N, 90 kg $ha^{-1}$ $P_2O_5$ and 60 kg $ha^{-1}$ $K_2O$ ). In the fall period, before planting of cover crops we have entered the entire amount of P and K in the forms of monopotassium phosphate plusadditional quantity of nitrogen 50 kg/ha by ammonium nitrate, and on the two control variants, also all of $P_2O_5$ i $K_2O$ and 40 kg $ha^{-1}$ N in the form AN.

In the next spring (May 20, 2014) leguminous cover crops had received another 30 kg $ha^{-1}$ N in the form of AN (remaining 40 kg $ha^{-1}$ considered to be provided by nitrogen fixation), oats an fodder kale 70 kg $ha^{-1}$ N, and control plots another 80 kg $ha^{-1}$ N, also in the form of AN. The experimental plots being ploughed in the autumn, have followed one pass of a disk harrow and a field cultivator prior to sowing. Sowing of cover crops were done manually in October 30, 2013.Mowing the above-ground biomass of winter cover crops were performed 7-10 days before planting of popcorn. Green mass of the cover crops was incorporated in the soil, immediately after, half of the elementary plot was infested with bio-fertilizer (BF) - Uniker (mobilizer of nutrients) in an amount of 10 l $ha^{-1}$(factor A), which contains the strains of cellulolytic and proteolytic bacteria to support the

mineralization of entered crop residues. Planting of popcorn seedlings were done on May 20,2014. Crops were harvested on October 07, 2014. The meteorological conditions during the growing season are presented in Table 1.

***Table 1***

***Average air temperatures and precipitation sums from April to September at ZemunPolje***

| Months | Temperature (°C) | Precipitation (mm) |
|---|---|---|
| April | 13.7 | 84.8 |
| May | 17.4 | 192.5 |
| June | 21.1 | 71.2 |
| July | 23.2 | 187.4 |
| August | 22.6 | 41.0 |
| September | 18.0 | 75.6 |
| Average/Sum | 19.3 | 652.5 |

More favourable conditions in term of quantity and distribution of precipitation were in the year of the investigation. Popcorn needs for precipitations depend on its development phase and they were lower at the beginning of growing period (about 100 mm), the highest (150–200 mm) in the period of flowering and ears formation. The year examination also characterized by optimal air temperatures, which has had an effect on the studied parameters grain yield of popcorn.

**Experimental design**

The experiment was in factorial setting with two factors in RCBD with four replications. Popcorn was sown in density of 65.000 plants $ha^{-1}$.The inter-row distance was 70 cm, while within-row plant distance was 22 cm. The new ZemunPolje (ZP) popcorn hybrids ZP 611k (FAO maturity group 600) was sown. The basic plot size was 16.8 $m^2$ (2.8 m by 6.0 m).

**Measurements and statistical analysis**

The yield data were underwent to ANOVA for the factorial trials set up according to the plan for one year, eight variants, where means differences were tested by the least significant difference (LSD) test.

## RESULTS AND DISCUSSIONS

Table 2 shows the grain yield of popcorn (hybrid ZP 611k) cultivated after various cover crops. Statistical analysis of the data obtained showed that statistically significant differences in grain yield depending on the type of cover crop. Based on a statistical analysis of the data in Table 2, we can point out that the microbiological fertilizer Uniker led to an increase in grain yield popcorn but the differences were not statistically significant. Popcorn may show large responses to microbial fertilizer applications depending on grown environment, the uniformity of the crop and the nutrient responses of the cultivated variety.

As for the cover crop, favorable effect on grain yield was achieved when the cover crop was winter fodder kale (5.25 t / ha) or a mixture of winter field pea and winter oat (5.40 t/ha). On the control plots gave the lowest yield in both versions without and with application of microbial fertilizer. A legume cover crop, such as common vetch, can supply most of N required for maximum maize yield (Bayer et al., 2000). In addition, vetch can improve soil water quality compared with bare fallow by reducing erosion during fall, winter, spring, and increasing organic matter. The grain yield of popcorn usually varied up on genotype and growth conditions (Tekkanatand Soylu, 2005).

**Table 2**

***The effect of different cover crops on the popcorn grain yield (t/ha)***

| Cover crops (B) | Microbiological fertilizer (A) | | Average (B) |
|---|---|---|---|
| | Without Uniker | With Uniker | |
| Common vetch | 5.09 | 5.13 | 5.11 |
| Winter oat | 3.96 | 4.94 | 4.45 |
| Fodder kale | 5.18 | 5.33 | 5.25 |
| Field pea+ Winter oat | 5.39 | 5.42 | 5.40 |
| Dead organic mulch | 4.10 | 4.10 | 4.10 |
| Common vetch + Winter oat | 4.42 | 5.03 | 4.72 |
| Field pea | 5.08 | 3.93 | 4.50 |
| Control (traditional treatment) | 4.77 | 4.85 | 4.81 |
| **Average (A)** | 4.75 | 4.84 | 4.79 |

| Factor | LSD (0.05) | LSD (0.01) |
|---|---|---|
| A | 0.389 | 0.520 |
| B | 0.779 | 1.041 |
| AB | 1.102 | 1.472 |

Dolijanović et al. (2016); Reiss et al. (2016) and Ranaldo et al. (2016) investigating the effects of different cover crops on weed infestation popcorn, found that the number of weeds in maize popcorn considerably smaller when growing cover crops, especially in problematic perennial species, which may be one of the reasons for the increase of grain yield of popcorn. The best results in the inhibition of weeds showed winter forage kale and mixtures of legumes and oats, and just after these cover crops maize hybrids ZP 611k by high yields.

## CONCLUSIONS

Based on the investigation of effects different cover crops on grain yield of popcorn can conclude the following:

Meteorological conditions in the examined period were extremely favourable, which contributed to an increase in yield and reduction in the efficiency of microbial fertilizer.

Investigation cover crops significantly influenced the grain yield of popcorn, a most notable winter leguminous crops and winter fodder kale, crops with a more developed aboveground biomass and greater coverability land.

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